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Syllabus for Math 1550 "Calculus I"

Text: Calculus, Early Transcendentals (2008) by Jon Rogawski

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This is a five (5) hour introductory calculus course designed primarily for engineering majors and certain other technical majors. As mentioned above, the text is the first edition book, Calculus, Early Transcendentals by Rogawski. The student is assumed to be versed in the standard pre-calculus topics of functions, graphing, solving equations and the exponential, logarithmic and trigonometric functions. The beginning instructor should be aware that some students may have issues with algebra and trig which might preclude their success in Calculus I. No prior exposure to Calculus is assumed by the instructors of this class. Since this is a five hour class, the students should be given at least three exams but four exams would be a much more reasonable number. However, the testing and evaluation of each class is entirely at the discretion of the instructor. No departmental policy exists on the use of sophisticated calculators in the calculus classes. The decision on which calculators to permit on exams is also left to the instructor. I am available to discuss the course with you. If you have questions please drop by my office to chat.

(Paul Britt)

Basic skills the students should acquire during the course

1. Limits and Continuity
 - a. Evaluate limits from a graph
 - b. Evaluate limits at points of continuity
 - c. Evaluate limits of indeterminate forms using algebraic simplifications and l'Hôpital's rule
 - d. Know what continuity implies about a graph and behavior of a function
 - e. Determine points of discontinuity for functions defined as formulas or graphs
2. Differentiation
 - a. Know the various interpretations of the derivative (velocity, rate of change, slope of tangent line)
 - b. Evaluate the derivatives of simple functions using a difference quotient
 - c. Evaluate the derivatives of combinations of the basic elementary functions
 - d. Take the derivative using implicit and logarithmic differentiation
 - e. Find tangent lines and be able to use them as linear approximations
 - f. Find critical values, local extrema and the intervals of concavity for differentiable functions
 - g. Find absolute extrema of constrained functions
 - h. Solve problems involving related rates
 - i. Solve basic optimization problems

j. Understand the Mean Value Theorem for Derivatives

3. Integration

- a. Understand anti-derivatives and know the basic anti-derivative formulas
- b. Have an understanding of the Riemann Integral as a limit of Riemann sums
- c. Be able to use both parts of the Fundamental Theorem
- d. Evaluate definite integrals using substitution
- e. Find the area between two curves and the volumes of solids of revolution
- f. Find arc lengths and areas of surfaces of revolution
- g. Understand the Mean Value Theorem for Integrals

A specific section by section syllabus and comments are shown below. A recommended set of homework problems is not provided. The textbook has a wide range of problems, from drill level through conceptual analysis. The instructor is urged to assign a broad range of problems from each section. Do not merely assign drill problems. The non-routine, challenging problems should form some part of each homework assignment.

Syllabus

Chapter 1

Optional. This is a pre-calculus review chapter and may be briefly discussed or assigned at the discretion of the instructor. While incoming students should be familiar with the topics in this chapter, some may be ill-prepared for calculus. Some faculty members have begun to require students to take a diagnostic test based on this first chapter. The test may show the student the pre-calculus areas they need to improve. Many faculty members simply skip this chapter.

Chapter 2

Section 2.1

Limits, rates of change and tangent lines: The author employs the notions of tangents and velocity to motivate the idea of a limit. Many students feel better about limits if they are given some sort of rationale for their study.

Section 2.2

Limits: A Numerical and Graphical Approach: This is the standard non-rigorous approach to limits. Most faculty members employ this sequential version of limits before giving the rigorous approach in Section 2.8. The students benefit from large numbers of examples, mainly graphical, but some numerical examples should be used as well.

Section 2.3

Basic Limit Laws: The standard theorems on limits of sums, differences, products, etc. are stated in this section. The proofs must be deferred until the rigorous definition of limits is covered in Section 2.8.

Section 2.4

Limits and Continuity: Continuity is, of course, one of the most important ideas in the course. The instructor should explore the topic in detail, so that confusion might be avoided later. The text uses the sequential criteria for continuity at points and then expands the discussion to intervals. One-sided continuity is discussed.

The students should be aware of continuity of the standard functions and how to combine them to make more complicated continuous functions.

Section 2.5

Evaluating Limits Algebraically: The students should be taught to evaluate limits of continuous functions with simple substitutions. The indeterminate forms will be difficult for many students. The instructor should present numerous examples of the various algebraic tricks involved in reducing indeterminate forms to continuous forms.

Section 2.6

Trigonometric Limits: This is a fairly standard section, with numerous homework problems based on the standard two trig limits one teaches in the first weeks of a calculus class.

Section 2.7

Intermediate Value Theorem: Attempts to justify the IVT for freshman may be a bit optimistic. Most instructors present the IVT and try to stress to students the notion of hypothesis and conclusion for theorems. Many students are quite good at remembering conclusions to theorems but never seem to remember that theorems have hypotheses. The instructor is advised to give examples where the IVT fails and demonstrate why it fails.

Section 2.8

The Formal Definition of a Limit: The instructor should use their own discretion in this section. This material is more abstract than most in this course. If you are new to teaching, you may wish to see the course coordinator (Paul Britt) or consult with some of your colleagues about this topic. When presented, it should be carefully and slowly explained. The author postpones limits at infinity until Chapter 4. The instructor may wish to simply include the precise definition of limits at infinity with the material in Section 2.8.

Chapter 3

Sections 3.1 and 3.2

Definition of the Derivative and the Derivative as a Function: This is the introduction to the derivative as limit of a difference quotient. The student should be made aware of the derivative as an instantaneous rate of change, a tangent line slope and the velocity of a particle. Too many students emerge from beginning calculus classes with an ability to compute difficult derivatives with little or no idea about the nature of the derivative. The instructor is advised to stress throughout the course the interpretation of what a derivative tells us. This is the section where that instruction begins. The students should be made familiar with the idea that differentiability means local linearity.

Section 3.3

Product and Quotient Rules: This is fairly standard presentation using these two powerful differentiation rules. The instructor can verify the rules and present numerous examples. Most students do not have much trouble with this topic.

Section 3.4

Rates of Change: This section stresses the rate of change and velocity interpretation of the derivative. This section gives examples of derivatives in use in

other fields. The students should know that derivatives have applications in courses other than math class. The section also continues the exposition about interpretation of the derivatives and reminds the students that a derivative is not simply a formula.

Section 3.5

Higher Derivatives: Standard presentation. Calculating general n th derivatives is a useful exercise in pattern recognition for the students. Be advised that mathematical induction is probably unknown to your students.

Section 3.6

Trigonometric Derivatives: The material is standard. The students may not recall as much trig as the instructor deems appropriate. On a somewhat related note, you will find that your students are largely unable to work basic identities or solve trig equations.

Section 3.7

The Chain Rule: This topic is troublesome for the student. The problem begins with their algebra weakness with composition. They cannot differentiate composite functions very easily because they do not really understand composition itself. The instructor will have to present a large number of examples.

Section 3.8

Implicit Differentiation: The beginning instructor should be advised that this seemingly easy topic will present their students many challenges. Do not suspect that you will be able to breeze through this material and have your students master it quickly.

Section 3.9

Derivatives of Inverse Functions: This section includes the derivative of an inverse function and the derivatives of the inverse trig functions. **Be advised that the author uses the anti-derivative prematurely on page 190.** You may wish to put that off until Section 4.9.

Section 3.10

Derivatives of General Exponential and Logarithmic Functions: This section produces the derivatives of exponential and logarithmic functions. This section also includes the derivatives of the hyperbolic functions and the inverse hyperbolic functions. You may consider the inverse hyperbolic functions as optional.

Section 3.11

Related Rates: This topic gives the students some trouble because they do not understand the chain rule. The two basic guidelines for related rate problems are: 1 – differentiate with respect to time and 2 – never substitute numerical values until you have differentiated. These two rules should help most students.

Chapter 4

Section 4.1

Linear Approximation and Applications: This section revisits the tangent line and refers to the linearization of functions. The instructor may wish to mention this is the best first degree polynomial approximation for a function. The book does not stress the notion of differential. The instructor should augment the textbook

presentation. The student should understand the geometric interpretations of dy and Δy .

Section 4.2

Extreme Values: This section includes the definitions involving local extrema, critical values, Fermat's Theorem and Rolle's Theorem. Stress the need for checking endpoints when finding extrema on closed intervals.

Section 4.3

The Mean Value Theorem and Monotonicity: The section includes the Mean Value Theorem, the implications of the sign of the first derivative and the first derivative test. The MVT is a building block for the proofs of many other theorems and should be carefully presented. The beginning instructor may be dismayed at their students' algebra skills when they try to find critical values.

Section 4.4

The Shape of a Graph: This section deals with concavity and inflection points and the second derivative test. Again, algebra deficiencies will plague many students. The instructor should stress that the second derivative's sign tells us about the rate of change for the first derivative. **Sections 4.3 and 4.4 are very important.**

Section 4.5

Graph Sketching and Asymptotes: This section summarizes graphing techniques and introduces limits at infinity. The author discusses horizontal and vertical asymptotes. The summary chart on page 255 is very important and useful.

Section 4.6

Applied Optimization: The students will encounter some difficulty in this section. They have forgotten geometry, needed for many of the geometric optimization problems. You should expect to spend more than one day on this topic.

Section 4.7

L'Hôpital's Rule: This is a fairly standard presentation.

Section 4.8

Newton's Method: This method of finding roots, while not robust, does offer the students reinforcements of the geometric interpretation of the derivative and the ideas of convergence. Demonstrations of cases where Newton's Method fails to converge should be presented.

Section 4.9

Antiderivatives: A fairly standard presentation.

Chapter 5

Section 5.1

Approximating and Computing Area: This section motivates the formal definition of the Riemann Integral in Section 5.2. This material is quite important, as it establishes the presence of sigma notation, left and right hand sums and the midpoint approximation.

Section 5.2

The Definite Integral: The instructor should carefully develop the definition of the Riemann Integral. This section also includes many of the basic properties of the

definite integral. The instructor should try to ground much of this section in geometric terms.

Section 5.3

The Fundamental Theorem of Calculus, Part I: Part I of the Fundamental

Theorem, the integral evaluation result, is given a standard presentation. Be aware that students often finish this class knowing only this first form of the Fundamental Theorem. You should point out to the students that many books refer to this as Part II of the FTC.

Section 5.4

The Fundamental Theorem of Calculus, Part II: This second form shows the beautiful interplay between the derivative and the integral. The instructor is encouraged to prove both parts of the FTC.

Section 5.5

Net or Total Change as the Integral of a Rate: This section is an extension of Section 5.3, involving the integral as total change of a function. Be certain to discuss the integrals representing displacement and total distance traveled. The cost applications, like most economic applications in this course, can be omitted.

Section 5.6

Substitution Method: Students have trouble with this topic. Since the idea of substitution is so important in Calculus II, the instructor should be very sure that his students receive adequate practice in this topic. The instructor should stress the need to change the limits of integration when evaluating a definite integral using substitution.

Section 5.7

Further Transcendental Functions: This brief section demonstrates the use of the integral to define certain non-algebraic functions. In particular, the natural logarithm is defined in the traditional manner in this section.

Section 5.8

Exponential Growth and Decay: Optional. This section is devoted to the differential equation governing the law of growth and decay. **The standard limits for e occur on page 362. These limits should be taught even if this section is skipped.**

Chapter 6

Section 6.1

Area Between Two Curves: This is a fairly standard presentation. Be sure to demonstrate some problems involving integration with respect to y .

Section 6.2

Setting Up Integrals: Volume, Density, Average Value: Many students have a great deal of difficulty with volume and density problems. The instruction should illustrate his examples with pictures (to the best of his ability). Be advised that even with marvelously drawn pictures the volumes by slicing problems represent some of the most challenging problems in Calculus I. The students do not "see" well in three dimensions. The instructor should be careful when assigning homework, as some of these slicing problems are difficult for the beginning student.

Section 6.3

Volumes of Revolution: These are volumes of solids of revolution, done with discs or washers. Remind the students that Riemann Rectangles rotated around an axis perpendicular to the rectangle form discs or washers.

Section 6.4

The Method of Cylindrical Shells: Similar to the above, many illustrations may make this topic easier for your students. Remind the students that when a Riemann Rectangle is rotated around an axis parallel to the rectangle a shell is formed.

Section 6.5

Work and Energy: This fairly standard physic topic may actually take two days to cover. The students have more trouble with the fluid pumping problems than with the other problems in this section. Be careful with the units.

Chapter 8

Section 8.1

Arc Length and Surface Area: Be advised that many of these integrals will be too difficult for the students since we are skipping Chapter 7. Of course, even if we covered Chapter 7 many of these integrals are non-elementary.

Sections 8.2 and 8.3

Fluid Pressure, Force and Center of Mass: These are standard topics from physics. The warning about troublesome integrals is again appropriate. Be certain of units. Remember, there is a difference between weight-density and mass-density.

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